LAYOUT GUIDE
FOR SMALL MEAT PLANTS

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LAYOUT GUIDE FOR SMALL MEAT PLANTS

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Given the requirements of the Wholesome Meat Act, as the 1967 revision of Federal Meat Inspection Act is commonly called, the average small meat processor has a choice of four courses of action: remodeling his plant to qualify for certification; building a new plant; confining himself to custom (exempt) work; or going out of business.

If he chooses remodeling or new construction, he will need guidelines for his builder to follow to assure that the plant will comply with inspection requirements. The guidelines set up by the U.S. Department of Agriculture for large packing plants do not meet all the needs of smaller operators. This report presents supplemental guidelines and sample layouts that were developed in a 2-year study, and assistance project for small meat processors in Texas and Oklahoma. The guidelines are generally applicable to all states, and they conform to Federal regulations.

Many small meat plants operating in Texas and Oklahoma today were built at least 20 years ago. Contractors and operators alike had little experience with this type of construction and relied on observation of existing facilities (often inadequate) for guidance in developing their plans. As a result, many plants were built to poor designs, using inappropriate materials. Such plants cannot meet the requirements for processing meats under Federal or State inspection; they also may be uneconomical to operate and create pollution problems (fig. 1).

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2 While no exact causal relationship has been established, about 100 small meat processors in Oklahoma and 500 in Texas have gone out of business since the law went into effect.

The more important deficiencies are—

1. Poor sanitation resulting from—
   a. Use of porous materials such as fiberboard, wood, and plasterboard for walls; rough concrete and wood for floors; and wood for work surfaces.
   b. Inadequate water and sewage facilities.
   c. Inadequate vermin control.
2. Inefficient plant layout.
   a. Too little space.
   b. Inconvenient workflow.
3. Pollution in the form of—
   a. Offensive odors.
   b. High solid and liquid waste concentrations discharged in ditches and streams.
4. Site problems.
   a. Difficulty of access.
   b. Inadequate parking space.
   c. Lack of room for expansion.

The need of small operators for assistance with plant design and layout has not gone totally unrecognized. Some meat industry suppliers have developed plans for purchasers of their equipment, and for some operators this service has been satisfactory. However, other operators felt that suppliers were more interested in selling hardware than providing efficient designs, and they turned to other sources for help.

This study was undertaken after the Meat Handling and Facilities Research group of Agricultural Research Service had received a number of requests from processors for assistance with plant design and layout. About 60 small operators were assisted over a 2-year period. Of these, about 40 percent chose to remodel, and the rest chose to build new plants. In addition, architects and builders were assisted in making plans for their customers. The researchers made no attempt to ascertain if any plan

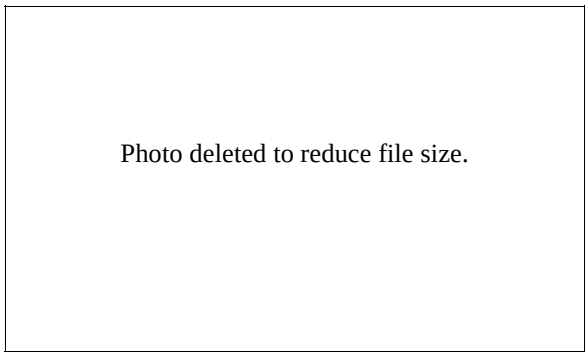

Figure 1. Small rural slaughter plant that discharged liquid wastes and hog hair into a drainage ditch.

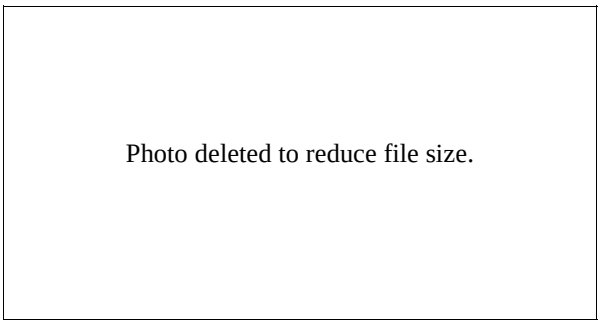

Figure 2. New slaughter plant in a business district.

represented a sound investment. The project has been evaluated, and the drawings and some of the information derived from it are presented here.

A small plant is defined as one that handles, on the average, 5 to 100 head per week. It may slaughter one or more species and may or may not chill the carcasses before shipping. It may slaughter only, fabricate only, or both; and it may produce either wholesale or customer cuts or both. It may freeze some of its production, rent locker or bulk frozen storage space, smoke some meats, and make sausage products. It may operate full time or only part time (the latter usually in conjunction with another business). It may be located in an isolated rural spot or a suburban shopping area—or even, in a few cases, downtown (fig. 2). The number of employees may range from 1 or 2 part time to more than 10 full time. Time spent in slaughtering may vary from 2 to 5 days per week. If the plant processes animals for sale, it must be inspected, either by State or Federal inspectors**.**

Designs suitable for large, medium, and small packing plants obviously do not coincide completely. The layouts and guidelines presented here are supplemental to, and include certain departures from the material presented in State and Federal handbooks. All such departures have been approved by the appropriate inspection officials.

Material is included on items such as plant site selection; plans for livestock holding pens, slaughter floors, hide houses, and waste treatment lagoon; plant layouts based on selected volumes and types of operation; and tabular data to aid in computing area requirements and equipment sizes. No attempt has been made to cover all acceptable variations of floor plans for various plant operations.

The Federal Meat Inspection Act sets forth the regulations governing meat inspection by the U. S. Department of Agriculture. To assist operators, architects, and contractors in designing plants to conform with the law, a Department publication titled "U.S. Inspected Meatpacking Plants: A Guide to Construction, Equipment, Layout" (Agriculture Handbook No. 191) is available for $2.65 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

PLANT SITE SELECTION

Anyone interested in new plant facilities should be aware of a number of important considerations in site selection in addition to land costs. Among the major factors are (1) customer accessibility, (2) utility availability, (3) land adequacy, (4) pollution potential, (5) zoning restrictions, and (6) meat inspection and health department requirements.

The plant should be on an all-weather road, at a location readily accessible to all customers. For an operator who' caters primarily to local customers, a town side street where land costs are relatively low may be a good location. An operator who has both local and out-of-town customers and wants to increase his volume

might advantageously build his plant on a well-traveled highway in a suburban area.

A dependable electrical supply is essential to plant operation. Natural gas, where available, has been the cheapest fuel. Because of the energy crisis, however, gas-operated equipment should not be purchased before verifying a dependable source of supply and a favorable gas-electricity cost relationship. Municipal water and sewer services are generally more reliable and cheaper than private wells and waste disposal by septic tank or lagoon on the property. Lack of one or more of these services could disqualify an otherwise desirable location, and in summary, it should always be determined if adequate 220-volt electric service is available, if existing gas lines or liquid petroleum gas (LPG) dealers can supply the volume needed, and if water and sewer lines are large enough to handle the expected volume.

Trial layouts should be made to insure that the proposed building and parking areas can be fitted on the site, leaving space for future expansion. Wide driveways, ample off-street parking for employee and customer vehicles, and plenty of maneuvering space for vehicles around the unloading and loading docks are essential. Landscaping should not be neglected, especially in town.

The plant site should have a low pollution factor; that is, be located in an area reasonably free of objectionable odors, smoke, flying ash, dust, and other pollutants (*11*)[3]. The land should be well drained and not subject to flooding.

Municipal and county land use plans should be checked for zoning restrictions before a site for a new plant is purchased. If the property is outside a zoned area, perhaps the appropriate planning board should be requested to zone the site and surrounding area for compatible

[3] *Italic numbers in parentheses refer to items in "Literature Cited," p.27*

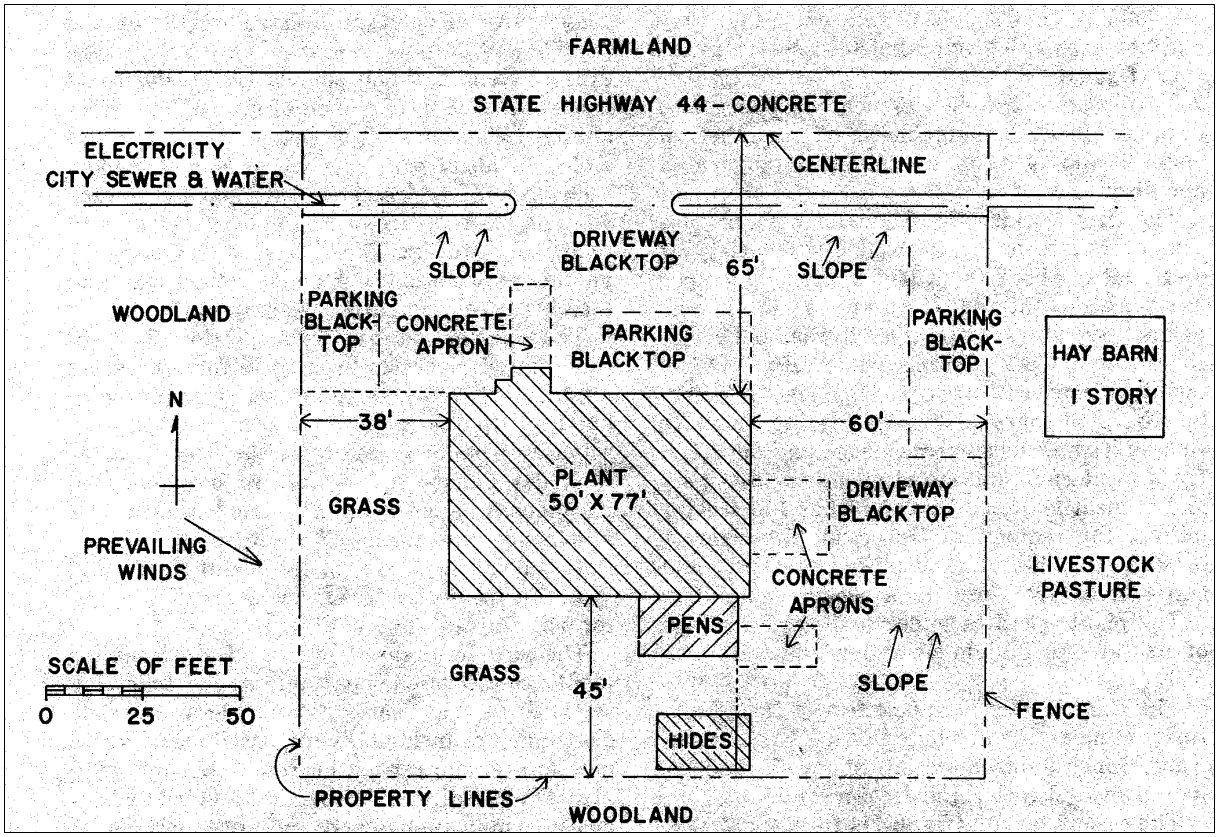

Figure 3. Plot plan for a small slaughter plant.

industry so that an objectionable business cannot be located nearby in the future.

The appropriate meat inspection and health department authorities should be consulted as to possible restrictions on the site. Since a plot plan is required when the plant plans are submitted for approval, it would be helpful to have the plot plan available for review at the first meeting with the authorities (fig. 3).

PLANT LAYOUTS

To design an efficient plant, the requirements for each component area and the interrelationships of the areas must be determined before tile layout is made. One important consideration in designing a plant, and the one most likely to be overlooked, is providing for possible future expansion. The design should allow for easy and economical expansion of areas such as the hold cooler, freezer, and dry storage. If possible, permanent installations such as refrigeration equipment, grease traps, water and sewer lines, and holding pens should be located so that they will not need to be relocated in case of expansion (fig. 4).

To illustrate the development of plans, two complete plant layouts based on hypothetical volumes and types of operation are presented and discussed.

The first layout (fig. 5) is for a plant that slaughters livestock and produces a variety of meat cuts. About 30 cattle and 30 hogs per week are slaughtered. Hogs are skinned. Some of the beef carcasses are aged in the hold cooler for about a week before cutting. About 1,500 pounds of pork cuts are cured and smoked weekly. The plant does custom processing and also slaughters and sells carcass sides and quarters, fresh meat cuts, and cured meats to customers and to meat markets. The plant has 140 freezer lockers for rental, and space for 585 freezer baskets. Inedible offal is picked up daily, and cattle hides are cured in a separate building.

The plant operates under inspection because of its sales to individual and wholesale customers.

The plant has 3,850 square feet of floor space. Inside dimensions are based on 9-inch exterior walls, 6-inch uninsulated interior walls, and 12-inch insulated cooler and freezer walls.

The second layout (fig. 6) is for a plant that does not slaughter. It receives beef and pork carcasses and wholesale cuts, and produces customer cuts. It grinds meats, forms patties, cures and smokes pork cuts and sausages, and rents freezer space to customers. About 25 beef carcasses with an average dressed weight of 400 pounds and 20 pork carcasses with an average dressed weight of 180 pounds are received and processed each week. Some of the beef quarters are aged about a week before processing. About 1,000 pounds of pork cuts are cured and smoked each week. Sixty freezer lockers and 450 freezer storage baskets are available for rental and temporary storage. Meat is sold to both individual and wholesale customers. Bones, fat, and inedible trimmings are picked up daily.

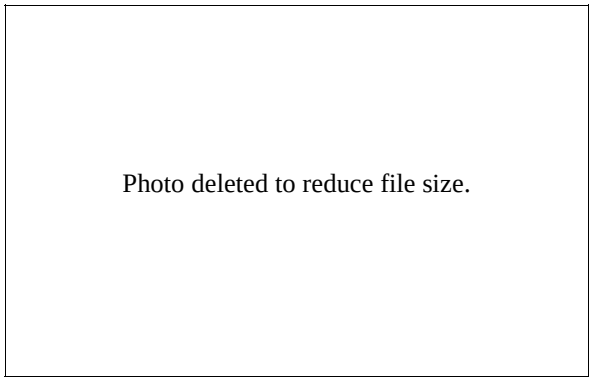

Figure 4. A freezer that can be expanded easily. Note that the refrigeration equipment is located on the roof

The plant operates under inspection. Custom-slaughtered carcasses brought in for processing are handled according to inspection regulations, but identified as to ownership on receipt, kept separate from inspected carcasses, and cut after each day's inspected meats are prepared and packaged. Custom cured and smoked meats are also handled separately from inspected meats.

This plant has 3,575 square feet of floor space. Wall thicknesses are the same as for the slaughter plant layout.

The various areas that comprise a complete plant are discussed separately in the following sections. In many cases, tabular data and scale drawings are included, some based on facilities now in use, and others, on research at existing plants, Federal meat-inspection and related industry publications, and recommendations of meat industry and equipment suppliers.

Livestock Unloading and Holding

All the slaughter plants studied had a facility for unloading livestock and holding them until slaughter. Since animals are delivered in vehicles with various bed heights, there is no optimum dock height for unloading. To minimize injuries to the livestock during unloading, a plant should have either several chutes of different heights (fig. 7) or an adjustable-height chute (fig. 8). Since most plants slaughter more than one species, the fences in the hold area should be capable of holding all species. From 2 to 6 pens should be ample since very few small plants slaughter more than 15 cattle or 20 hogs a day.

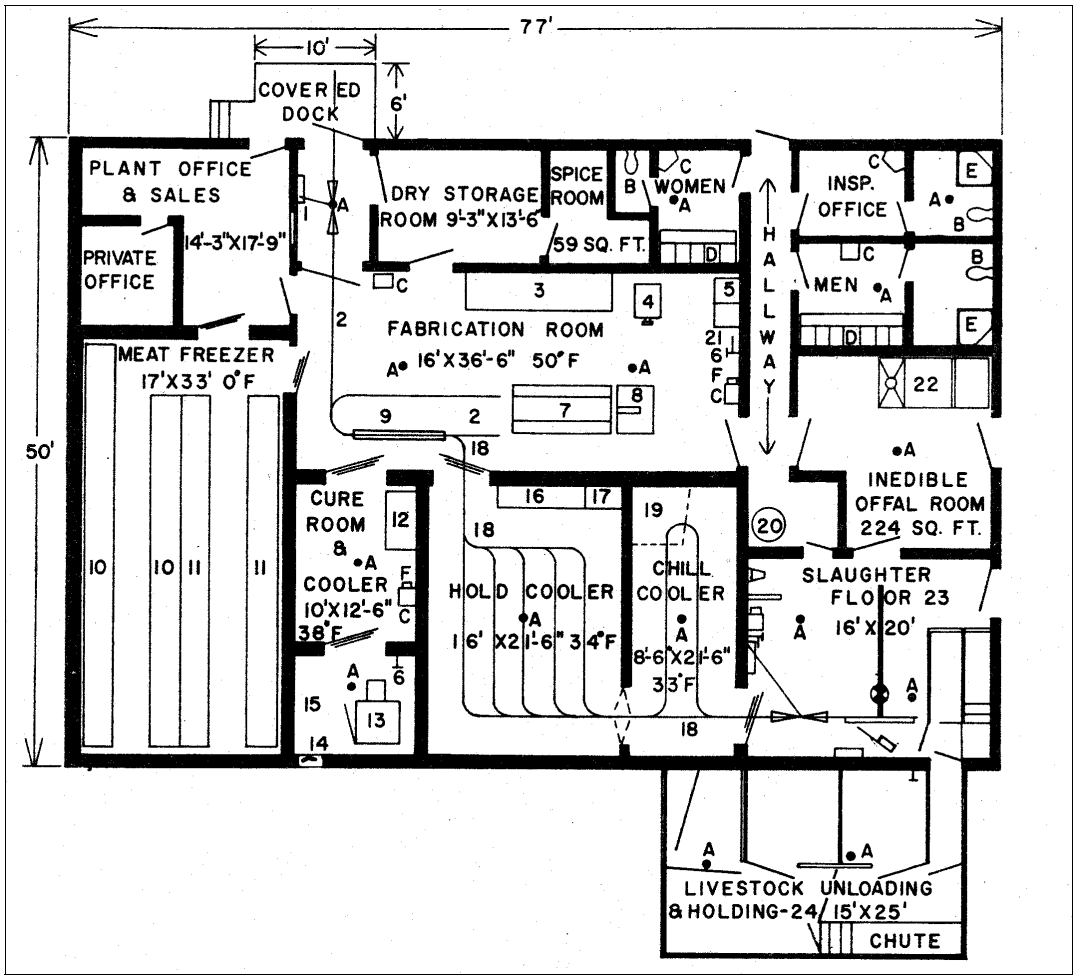

FIGURE 5.—Layout for a slaughter plant. (1) Track scale, (2) 7'6" high rail, (3) packing table, (4) meat grinder, (5) sink, (6) hot and cold water, (7) boning table, (8) bandsaw, (9) quarter dropper, (10) meat baskets, (11) meat lockers, (12) ham-pump table, (13) smokehouse, (14) exhaust fan, (15) smoke room 8'X10', (16) meat shelves, (17) return products, (18) 11' high rail, (19) collapsible retaining cage, (20) water heater 180° F, (21) thermometer in waterline, (22) paunch work table, (23) details on figure 11, (24) details on figure 9, (A) floor drain, (B) toilet, (C) lavatory, (D) clothing locker, (E) shower, and (F) sterilizer.

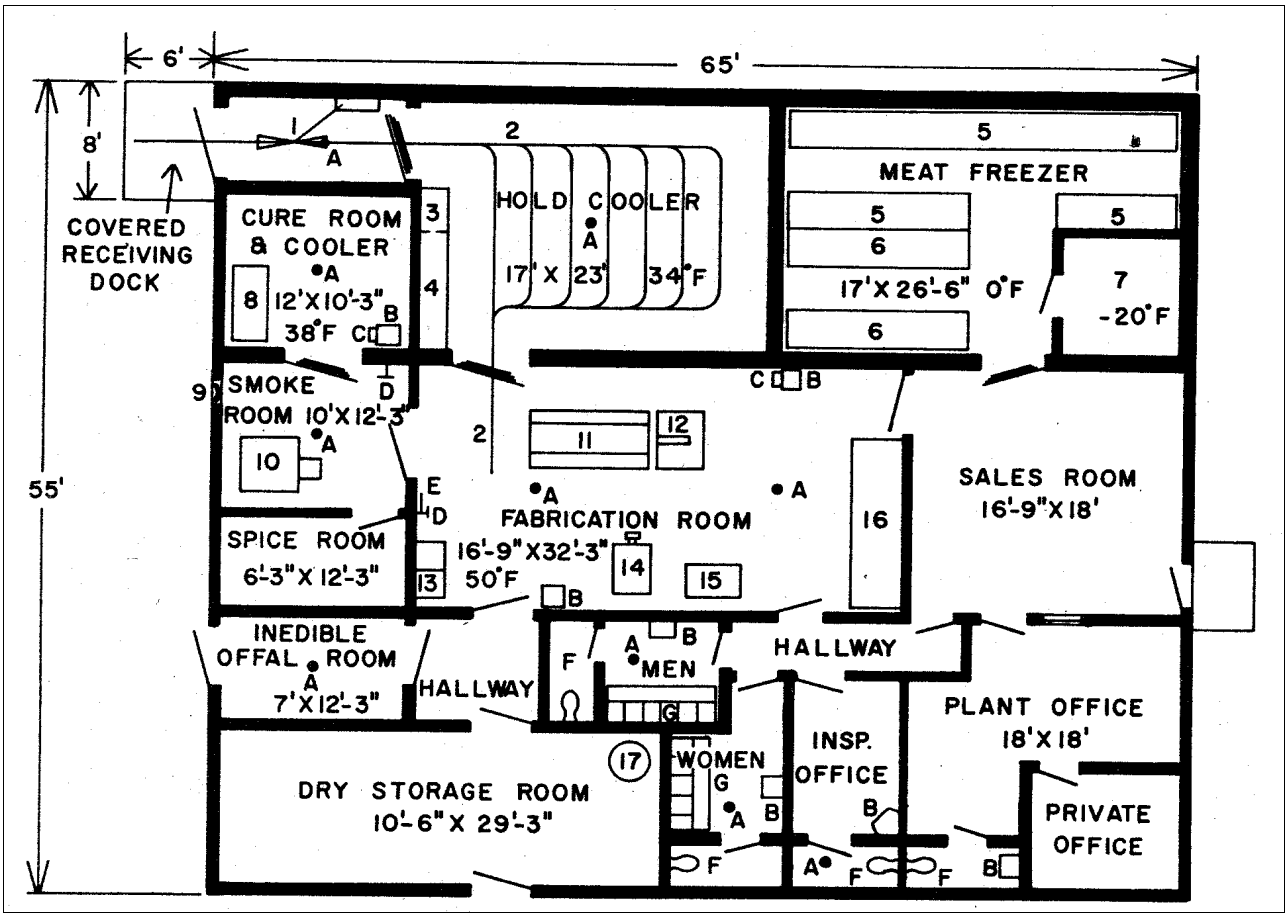

FIGURE 6.—Layout for a nonslaughter plant. (1) Track scale, (2) 7'6" high rail, (3) return product, (4) meat shelves, (5) meat baskets, (6) meat lockers, (7) quick freezer 8'x8', (8) ham-pump table, (9) exhaust fan, (10) smokehouse, (11) boning table, (12) bandsaw, (13) sink, (14) meat grinder, (15) patty machine, (16) packing table, (17) water heater 140° F, (A) floor drain, (B,) lavatory, (C) sterilizer, (D) hot and cold water, (E) thermometer in waterline, (F) toilet, and (G) clothing locker.

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An adjustable-height chute is recommended as the most efficient way to handle livestock unloading from all types and sizes of vehicles. One design for such a chute is shown in figure 9. Once the chute floor is adjusted to the level of the vehicle bed, a retainer rod can be placed under the chute floor to hold it during unloading. A counterweight and cable arrangement can be rigged for ease in lifting the vehicle end of the floor. The floor should have an easy-to-clean, nonslip surface and be about 2½ feet wide and 8½ feet long. The "off" end can be pivoted on a concrete platform 1 foot high, 2½ feet wide, and 4½ feet long.

The holding area is also shown in figure 9. Unloaded livestock are driven into an alley that opens into the suspect pen, two hold pens, and the chute to the stun pen. The alley has a block

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gate to aid in moving animals into and out of pens and also to divide the alley into two temporary hold pens when needed. Next to the chute is an access door for workers.

The suspect pen has a 7-foot-long squeeze gate (for restraining an animal during ante-mortem inspection) and a 7-foot-wide alley gate. A removable water trough is provided for animals held overnight. The suspect pen can be used as a hold pen after suspect animals have been removed and the pen has been cleaned and disinfected.

The two hold pens have 4¼-foot-wide alley gates and share a removable water trough. The 15-foot holding-pen area will accommodate three 5-foot pens, if desired.

The chute leading from the alley to the slaughter floor has a 3-foot-wide gate opening into the alley. This chute can be used as a worker walk-

Figure 8. Adjustable unloading chute.

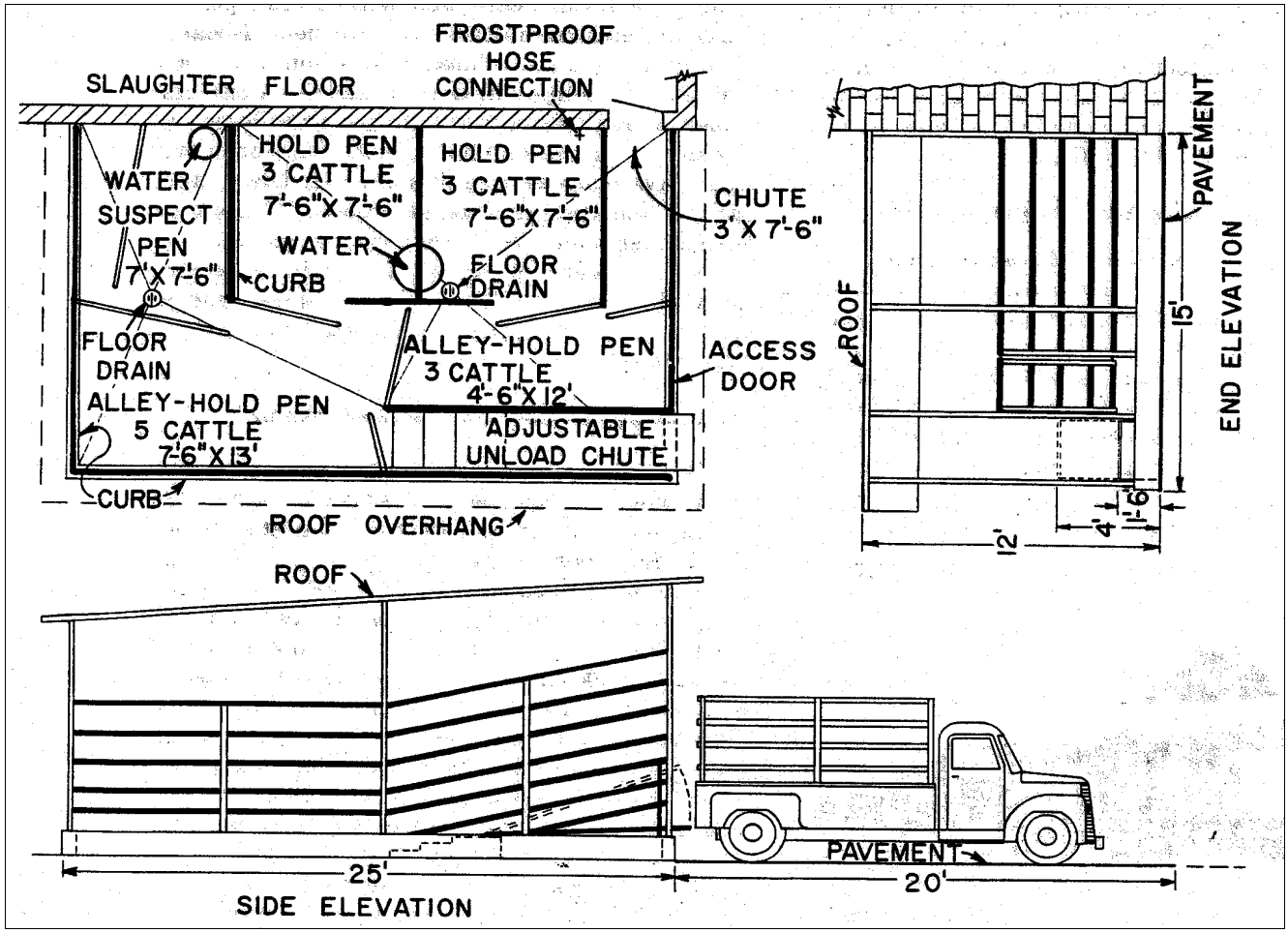

Figure 9. Adjustable-height unload-chute and hold-pen layout.

way or a pen to hold one animal for quick delivery to the stun pen.

The capacity of the 2 hold pens, the suspect pen, and the alley taken together is 16 cattle, 18 hogs, or combination of the two**,** allowing 18 square feet per head for cattle and 6 square feet per. head for hogs (4). This hold-pen capacity and layout are suggested for the slaughter plant shown in figure 5.

The unloading and holding area fences should be built of durable easy-to-clean materials. Smooth rounded edges reduce the chances for injury or bruises to animals during handling. Rust-resistant pipe is recommended for fencing, and slightly rough concrete is recommended for the floor. To control contamination, a concrete curb 12 inches high under the fence between the suspect pen and adjacent pen is suggested. A separate floor drain in the suspect pen also is recommended. For washing pen floors and filling water troughs, there is a frost proof cold-water hose connection in one of the holding pens. A shed roof over the entire area is suggested to protect animals and workers from inclement weather (fig. 10).

Slaughter Floors

In the plants studied, slaughter floors fell into two size classes. The smaller floors handle only 1 carcass at a time, and daily volume averages less than 15 head. One butcher or a butcher and a helper usually operate such a floor. If only a few hogs are slaughtered or no pork is cured, all carcasses are skinned. Plants that handle many hogs or prepare much cured pork may remove the hair from hogs, requiring floor area for a scald vat or vat and dehairer.

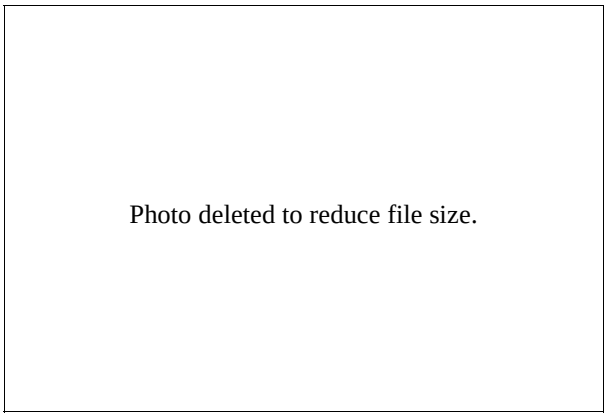

Figure 10. Covered hold pens. Note sturdy pipe fences.

The larger slaughter floors accommodate more than one carcass at a time. Daily volume may exceed 30 carcasses, depending on crew size, species and weight of animals handled, byproducts saved, type and amount of equipment used, and room size. At least two butchers and one or more helpers normally work on the larger floors. The factors that apply to skinning and dehairing of hogs are as previously listed.

The slaughter rate for workers on any floor is limited by the space available, the kind and arrangement of equipment, and the number of job-related duties performed by the workers. One to 1 1/4 carcasses per man-hour is typical.

All slaughter floors have the same types of equipment; however, the larger floor normally has more and higher capacity equipment, to reduce labor requirements and improve inspection procedures.

Most floors are equipped with a stun pen, a traveling electric hoist on an overhead I-beam, a skinning cradle, a head-inspection rack, an overhead dressing rail that extends to a carcass cooler, a track scale to weigh carcasses hung on trolleys, a carcass-splitting saw, one or more wash lavatories and equipment sterilizers, and carcass washing and cleanup hoses. If pork is cured, there may be a scald vat or vat and dehairer. A viscera inspection truck with an upper inspection pan for the pluck and spleen and a lower pan for the viscera is probably needed at most plants.

Small slaughter floor—all carcasses skinned

The least space is needed for the slaughter floor when all species are skinned (fig. 11). If the stun pen is outside the slaughter floor, the 20-foot room length shown in figure 11 can be reduced to about 15 feet; 18 feet is adequate if a stun pen with built-in head restrainer is used. This type of stun pen does not need an elevated walkway for the stunner. The layout is drawn to scale, and the most important room dimensions and locations of some equipment items are shown in the figure. The slaughter floor shown in figure 11 is recommended for the slaughter plant layout, since the average daily volume should not exceed 15 head.

The livestock stun pen can be made up by the plant builder (fig. 12) or purchased from an equipment supplier (fig. 13). If it is homemade, smooth metal should be used and all

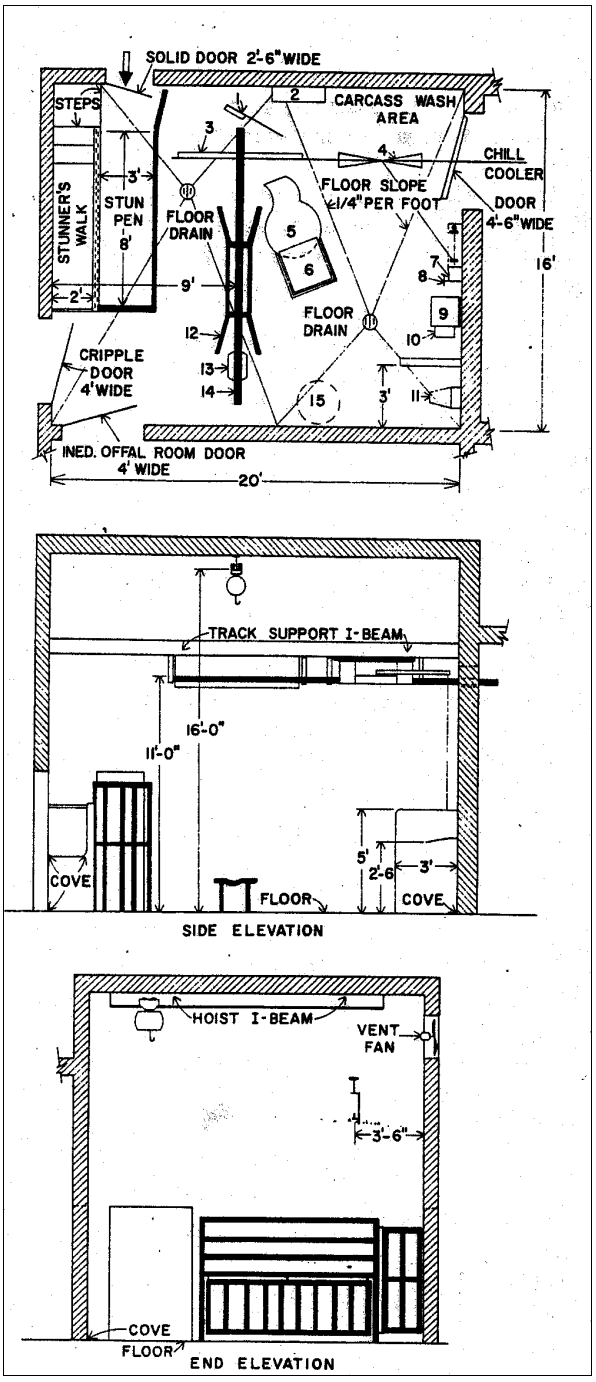

Figure 11.—Suggested layout for small slaughter floor where all carcasses are skinned. (1) Carcass saw, (2) saw sterilizer, (3) carcass lander, (4) track scale, (5) viscera inspection truck, (6) inspection pan, (7) thermometer, (8) hot and cold water, (9) lavatory, (10) equipment sterilizer, (11) head inspection rack, (12) portable skinning cradle, (13) hoist, (14) I-beam, and (15) inedible container.

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Figure 12. Stun pen constructed by the plant builder.

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Figure 13. Purchased stun pen with built-in head restrainer.

welded joints ground smooth. The completed pen should be coated with an approved nontoxic rust-resistant finish.

The stunned-animal discharge door shown in figure 11 is about 7½ feet long and 2 ¾ feet high. It is hinged to the stun pen frame along the top edge. A counterweight with cables attached to the door can be used to swing the door open when the latch is released. Since this size of slaughter floor does not have a safety fence around the dry-land area, a restraining device such as a galvanized neck chain is needed to prevent improperly stunned animals from escaping when discharged from the stun pen. A closely spaced pipe or solid-metal vertical sliding gate is needed at the entrance to the stun pen.

A penetrating or nonpenetrating captive head or similar stunner must be employed to render livestock unconscious if head and cheek meat is to be saved. The brain can be saved only when it is not damaged by the stunning device. A blank cartridge powers most stunners. So that the worker can be above the animal when he stuns it, an elevated walkway about 2 feet wide and 2½ feet above the room floor is recommended. A solid masonry or pipe wall about 6 feet high can be used to separate the stun pen from the elevated walkway (fig. 14).

A space about 2½ feet wide and 3 feet deep between the entrance gate to the stun pen and the slaughter floor wall allows a worker to go from the slaughter floor directly to the outside chute pen or to the stunner's walkway. A gate between the room wall and stun pen prevents animals from entering the slaughter floor when they are driven into the stun pen. A solid rust-resistant metal door in the room wall can prevent an animal from entering the stun pen ahead of time and also keep out inclement weather, insects, and rodents.

An electric exhaust fan in one wall will help ventilate the room as required. The fan opening should be screened and equipped with shutters that open only when the fan is on.

An electric hoist attached to tandem trolleys and hung on an I-beam is suggested to hoist the stunned carcass for bleeding, transfer the carcass to the skinning cradle, and transfer the partially skinned carcass to the overhead dressing rail (fig. 15). The hoist also has a minimum lifting speed of 16 feet per minute (preferably 32 feet) and enough power to drag a crippled animal from a vehicle outside to the slaughter area. A 2,000-pound capacity is necessary if mature cattle are slaughtered; a 1,000-pound-capacity hoist will do if only light calves and hogs are slaughtered.

The size of the traveling-hoist I-beam de-

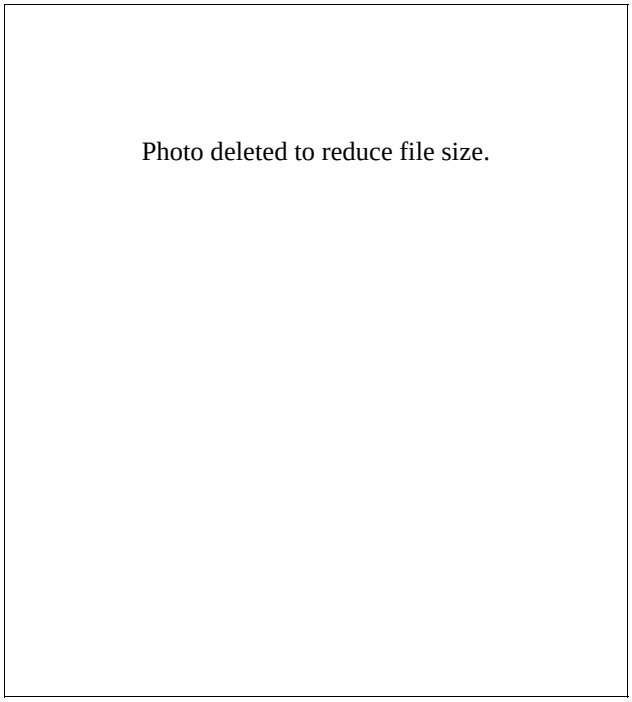

Figure 14. Elevated stunner's walkway. The door in the background opens into the hold-pen area.

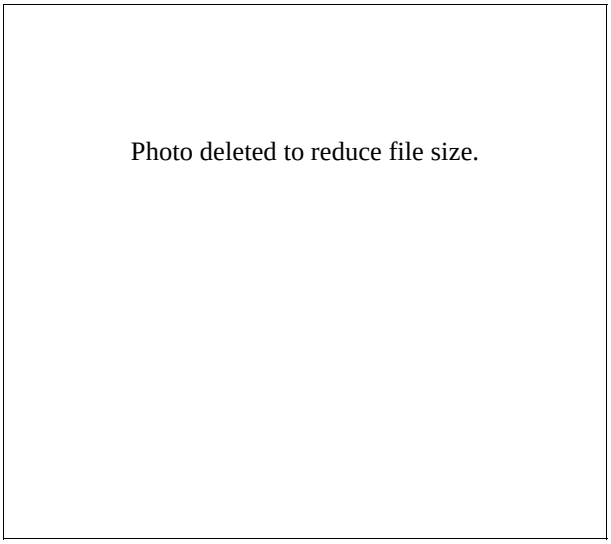

Figure 15. Traveling electric chain hoist for handling a carcass during slaughter operations.

pends on the type of support provided and the weight of the hoist and livestock slaughtered. If a 2,000-pound-capacity traveling hoist is needed, it is recommended that an American standard I-beam be used with either a 6-inch web supported every 10 feet or an 8-inch web supported every 17 feet. For a 1,000-pound-capacity hoist, a 5-inch web supported every 11 feet is suggested. Most trolley wheels can be adjusted to operate on an I-beam flange from 5 to 12 inches wide.

A portable skinning cradle is preferred on this size of slaughter floor so that it can be moved out of the way when not in use. It can be purchased from an equipment supplier or made of metal tubing, coated with an approved finish after welding, and mounted on castors equipped with brakes. The minimum recommended cradle height is 12 inches; tubing diameter should be 1 ½ to 2 inches. The cradle length can range from 5 to 8 feet, depending on need. The distance between the two parallel tubes that support the carcass on its back should be adjustable from about 8 to 14 inches so that all carcass sizes can be handled.

After a carcass is skinned, eviscerated, and split (sawed) into two sides, a single-rail lander is most efficient for transferring the carcass from the spreader to the overhead rail. Unless a lander is used, a worker either has to stand on a platform or ladder and manually guide the carcass on the spreader to two trolleys he has placed on the overhead rail or he has to stand on the floor and use a roller pole to place trolleys on the rail and steady each trolley during carcass transfer. Both of these latter methods are unsatisfactory.

The overhead rail should be 3/8- by 2½-inch, high-quality, hot-rolled steel. It should not be painted after installation. Galvanized rails are not recommended because the trolley wheels can flake the metal coating off the rail onto the carcass meat. To prevent rust, an approved food-grade oil should be applied to the rail each time it is cleaned. Either 10- or 12-inch-long track hangers on approximately 30-inch centers can be used to suspend the rail from ceiling supports, wood or steel beams supported by the room walls, or a separate wood or metal framework. The suggested figures for computing load per linear foot of overhead rail, including a safety factor, are 1,000 pounds for large bulls, 575 pounds for' average-weight cattle, and 400 pounds for lightweight calves and hogs.

A track scale with beam weight indicator is recommended since it can be just as accurate as the dial type and costs about one-half as much. The vertical distance between the top of the rail and the lowest part of the supporting beams over the scale determines if a deep- or shallow-pattern scale is used. For the deep-pattern scale, a clearance of at least 20 inches is required; the shallow pattern must be used if clearance is less than 20 inches. The selection of scale capacity and weight graduations should be based on the type of livestock slaughtered.

A wall-mounted head inspection rack is located in one corner of the room (fig. 16). If a hook is provided on the lower crossbar of the head rack, the carcass head can be suspended on it for washing prior to display on the inspection rack *(10).* The head loop and hook should be stainless steel. After inspection, the tongue, head, and cheek meat can be removed while the head is still on the loop *(10).*

Two floor drains are suggested for the slaughter floor to localize the flow of waste water, so that some cleaning can be done while a carcass is being dressed. Packinghouse-type cast-iron floor drains with removable covers are preferred. A combination blood and water floor drain is needed in the bleed area if blood is to be drained into a tank or vat.

The interior walls, floor, and ceiling should be carefully installed by competent workers. Plumb smooth walls, an uncluttered ceiling, and an evenly sloped floor are easier to clean and maintain in sanitary condition. Durable flooring such as concrete, ceramic floor tile, floor brick, or other approved materials must be used. A too smooth floor must be avoided since it can be slick when wet and create a safety problem and reduced efficiency. The authors have seen workers lose their footing and, in general, perform their jobs more slowly and cautiously because of slippery conditions. On the other hand, if the floor surface is too rough, it is impossible to clean properly.

Some recommended wall finishes are glazed brick or tile, smooth-surface portland cement plaster, and paneling of such materials as non-toxic rust-resistant metal or fiberglass, and plastic. Ceiling finishes include the cement plaster, the panels listed for walls, and large-

size cement-asbestos boards. The surface of the wall and ceiling should not be painted since most paints crack and peel after a relatively short exposure to high humidity and frequent cleaning. The cove at the junction of floor and walls should have at least a ½ inch radius for easy cleaning. Cove edges should be flush with the finish surface of the adjacent wall or floor.

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Figure 16. Head wash and inspection cabinet.

Small slaughter floor—cattle skinned, hogs scalded and dehaired

A layout for a one-at-a-time slaughter floor equipped with a hog scald vat and dehairer is shown in figure 17. The only major change from the previous layout is the addition of the scald vat and dehairer. A one-hog scald vat with thermostatic control for water temperature is recommended; it should have a drain at one end and be made of approved nontoxic rust-resistant materials (fig. 18).

Before the decision is made to install a hog scald vat and dehairer, the operator should try to determine if the profit from this investment would justify it. Some factors to be considered are (1) the difference in the selling price of dehaired and skinned carcasses, (2) the effect on volume handled if only skinned hog carcasses are produced, (3) the cost for additional floor space, and (4) the cost of owning and operating the equipment.

This discussion is limited to the fourth factor

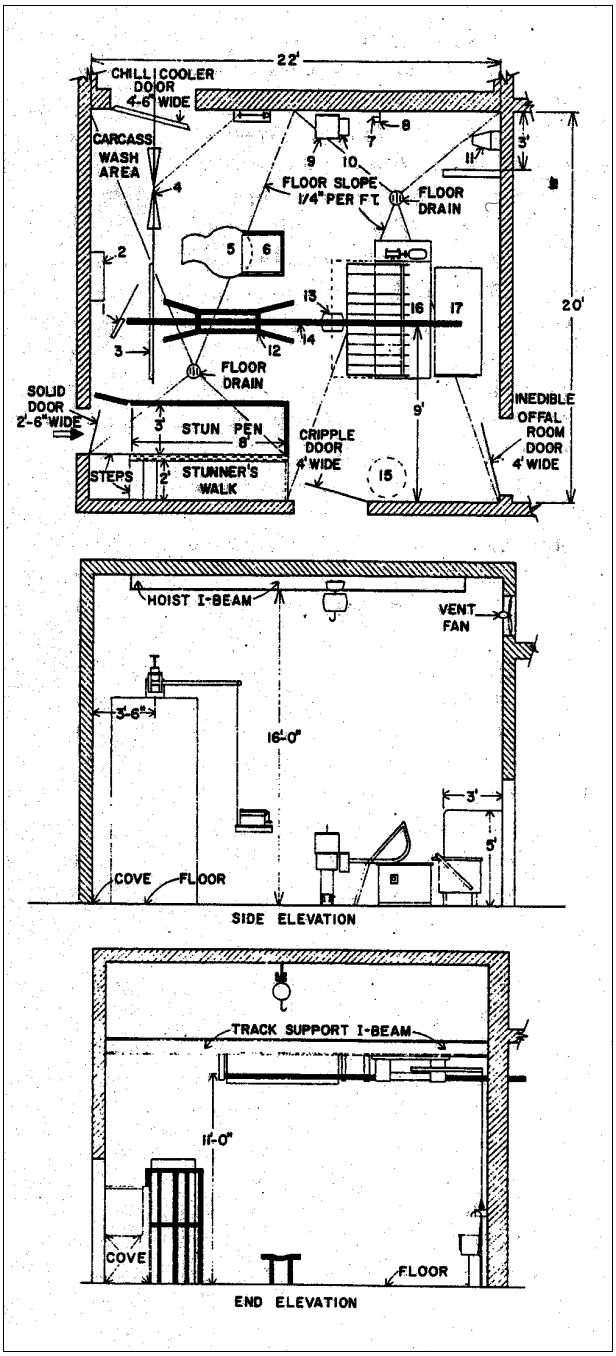

Figure 17.—Suggested layout for small slaughter floor where cattle are skinned and hogs are scalded and dehaired. (1) Carcass saw, (2) saw sterilizer, (3) carcass lander, (4) track scale, (5) viscera inspection truck, (6) inspection pan, (7) thermometer, (8) hot and cold water, (9) lavatory, (10) equipment sterilizer, (11) head inspection rack, (12) portable skinning cradle, (13) hoist, (14) I-beam, (15) inedible container, (16) dehairer, and (17) scald vat.

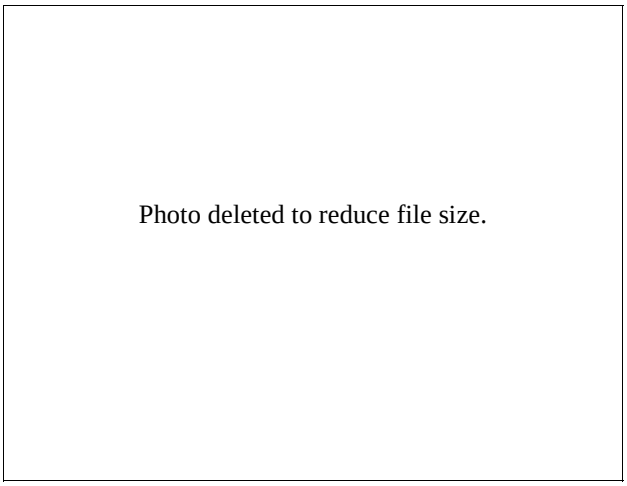

Figure 18. Hog scald vat and dehairer in a small plant.

since the operator should be able to answer the first two and the builder can estimate the floor space costs. The estimated total annual cost and per-hog cost to own and operate a scald vat and dehairer for selected slaughter schedules and annual volumes are shown in table 1. When hogs are slaughtered, scalded, and dehaired on 1 day each week and the average weekly number is 10 head (520 head per year), the total equipment cost per hog is about $0.97. Approximately 79 percent of the $0.97 is ownership cost and 21 percent is operating cost. If hog slaughter is scheduled 3 days each week and about 40 head are handled a week (2,080 head per year), the equipment cost per hog is about $0.32. With 3 slaughter days per week and a larger volume, ownership cost is reduced to approximately 59 percent of the total cost per hog. Ownership

Table 1. Equipment ownership and operating costs for a scald vat and a dehairer for selected hog slaughter schedules and annual volumes.

Equipment slaughter schedule and annual volume	Total installed Cost [1]	Annual cost			Cents per hog
		Ownership [2]	Operation [3]	Total	
Scald vat, 1-hog					
52 slaughter days:					
520 head	$936.25	$148.84	$75.19	$224.03	43.08
780 head	936.25	148.84	75.40	224.24	28.75
104 slaughter days:					
1,140 head	936.25	148.84	127.28	276.12	26.55
1,300 head	936.25	148.84	127.49	276.33	21.26
1,560 head	936.25	148.84	127.70	276.54	17.73
156 slaughter days:					
1,820 head	936.25	148.84	179.58	328.42	18.05
2,080 head	936.25	148.84	179.78	328.62	15.80
Dehairer:					
52 slaughter days:					
520 head	1,576.50	250.26	32.08	282.34	54.30
780 head	1,576.50	250.26	39.21	289.47	37.11
104 slaughter days:					
1,040 head	1,576.50	250.26	57.25	307.51	29.57
1,300 head	1,576.50	250.26	64.18	314.44	24.19
1,560 head	1,576.50	250.26	71.20	321.46	20.61
156 slaughter days:					
1,820 head	1,576.50	250.26	89.53	339.79	18.67
2,080 head	1,576.50	250.26	96.46	346.72	16.67

[1] Includes the 1974 purchase price plus an allowance for shipping 500 miles and for installing the equipment in the plant.

[2] Includes depreciation based on an expected life of 12 years computed using the straight-line method with a salvage value equal to 10 percent of the purchase price; interest on investment based on 8½ percent of one-half of the installed cost; and insurance and taxes based on 4 percent of the installed cost (9).

[3] Includes utilities based on water at 0.08 cent per gallon, natural gas at 0.10 cent per cubic foot, and electricity at 2.45 cents per kilowatt-hour; and maintenance for the scald vat estimated at 3 percent of the purchase price and for the dehairer based on an assumed life of 2,000 hours for the electric motor and 48,000 hogs for the scraper paddles.

costs are classified as fixed costs and include depreciation, interest on investment, and insurance and taxes. Operating costs are variable, and as the number of days used increases, they also increase, but at a decreasing rate. Operating costs include utility charges for water, gas, and electricity, and maintenance of the equipment in good working order. No allowance is made in table 1 for labor costs for workers attending the two machines, waiting while hogs are scalded and dehaired, or cleaning the equipment at the end of the day. Nor are building costs included in the table.

Large slaughter floor—all carcasses skinned

Figure 19 shows a suggested layout for a multiple-head slaughter floor and a portion of the inedible-offal room. The offal room section is shown to locate a paunch-truck sterilizing area and the hose connection for 180° F water, required for sterilizing paunch trucks and for cleaning the slaughter floor when a carcass is condemned *(11)*.

Meat inspection officials probably would limit this floor to three carcasses at a time, since only three carcass heads can be identified at one time with the carcasses being dressed. The carcass heads are located in a single-head flush cabinet and on two head-inspection loops.

The room shape, size, and equipment arrangement are planned for efficient operation with either a large or small work crew. A ceiling height of at least 17 feet is recommended for the entire floor, since the I-beam for the traveling hoist over the dry-land, bleed, and skin areas and the support for the fixed hoist at the carcass lander require a 16 foot vertical clearance (11).

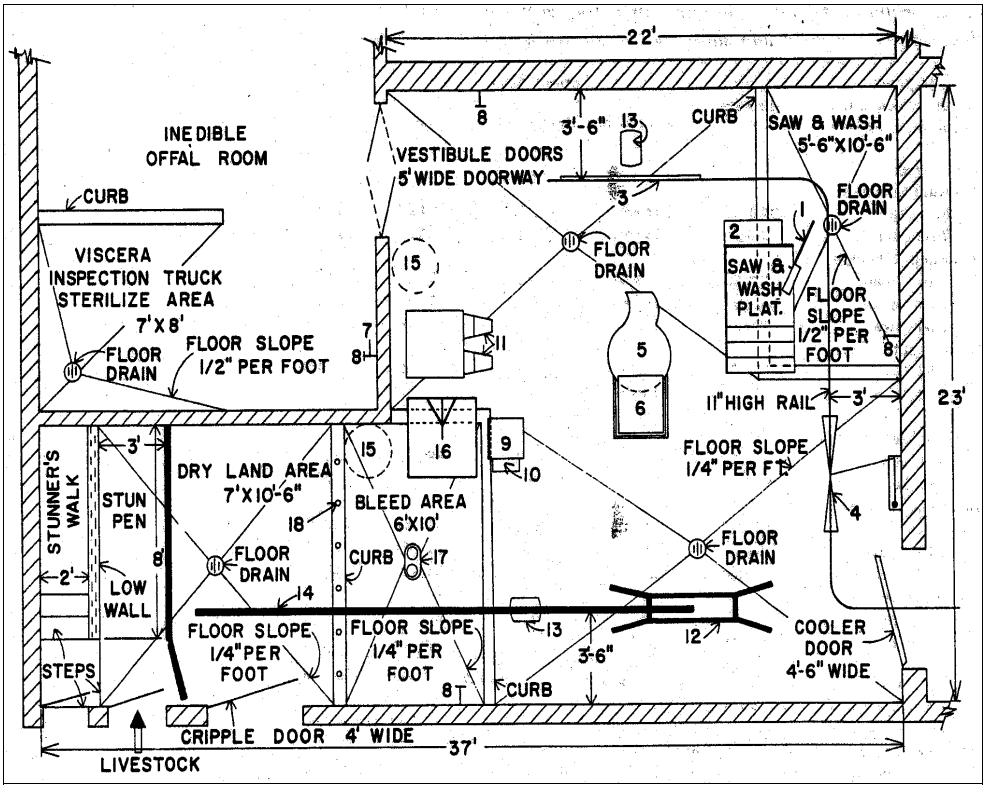

FIGURE 19.—Suggested layout for slaughter floor handling more than one head at a time, where all carcasses are skinned. (1) Carcass saw, (2) saw sterilizer, (3) carcass lander, (4) track scale, (5) viscera inspection truck, (6) inspection pan, (7) thermometer, (8) hot and cold water, (9) lavatory, (10) equipment sterilizer, (11) head inspection loops, (12) skinning cradle**,** (13) hoist, (14) I-beam 16' high, (15) inedible container, (16) head flush cabinet, (17) blood and water drain, and (18) safety fence.

Curbs are used around the dry—land and bleed areas and the carcass saw and wash area to allow for each floor area to be washed and drained separately. They may be concrete, about 6 inches wide and 6 inches high (fig. 20) . The curb between the dry-land and bleed areas should have a safety fence to prevent improperly stunned animals from leaving the dry—land area. The safety fence may be made of 2-inch pipes spaced 16 inches apart, and extending about 48 inches above the curb *(11)*.

A few pieces of equipment beyond those needed on the smaller floors have been added to create more work areas for improved efficiency. For example, by adding a separate head inspection table with head loops, the head flush cabinet is freed for washing heads only and need not be used as an inspection cabinet. A fixed hoist is provided to transfer the partially skinned carcass to the half-hoist area where the rump and back are skinned and the carcass is eviscerated. The carcass is landed on the dressing rail by this hoist.

Three hot and cold water hose connections are provided to increase wash down efficiency during slaughter. One of these is for cleaning the dry-land, bleed, and skin areas; another, to hose down the half-hoist area; and the third, to wash carcasses.

Meat Coolers

Most slaughter plants have a chill cooler for removing the body heat from freshly slaughtered carcasses and a hold or sales cooler to store carcasses until they are processed or sold. A few small-volume plants chill and store carcasses in the same cooler. None of the small plants studied had a separate edible byproducts cooler; these items are usually hung on trolley trees in the carcass coolers. Meat plants that don't slaughter have a cooler for storing fresh carcasses. Plants may also have part of a cooler or a separate one for game and custom-slaughtered carcasses (fig. 21). Both slaughter and nonslaughter plants have a cure cooler if they handle enough volume to justify one.

Efficient coolers require insulation in floors, walls, and ceilings. A good vapor barrier on the warm side of the insulation helps prevent moisture migration, which would reduce the insulation's efficiency (fig. 22).

Refrigeration capacity should be based on the total load under peak conditions. Self-contained or remote refrigeration systems are used in these plants. A self-contained system combines the condensing unit and refrigeration coil in a single unit. It can be mounted through an outside cooler wall or through the roof above the cooler. In a remote system the coil is mounted in the

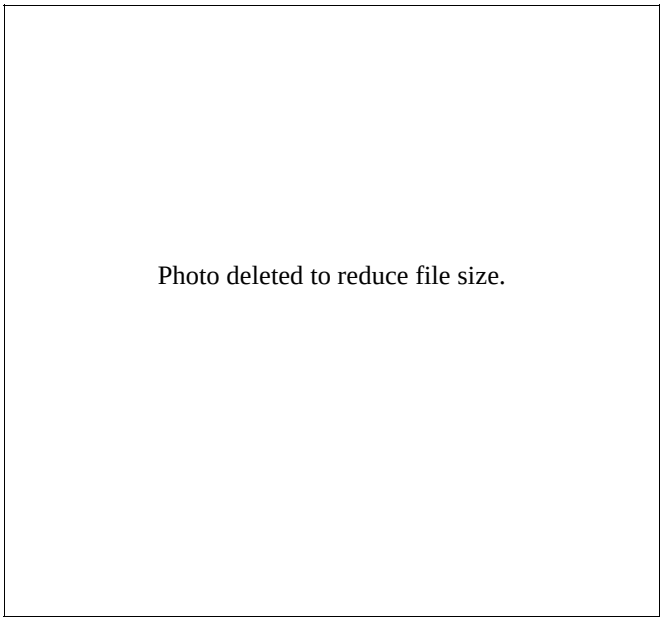

Figure 20. Dry-land area in a plant. The stun pen door and chain hoist hook and control are visible in the background

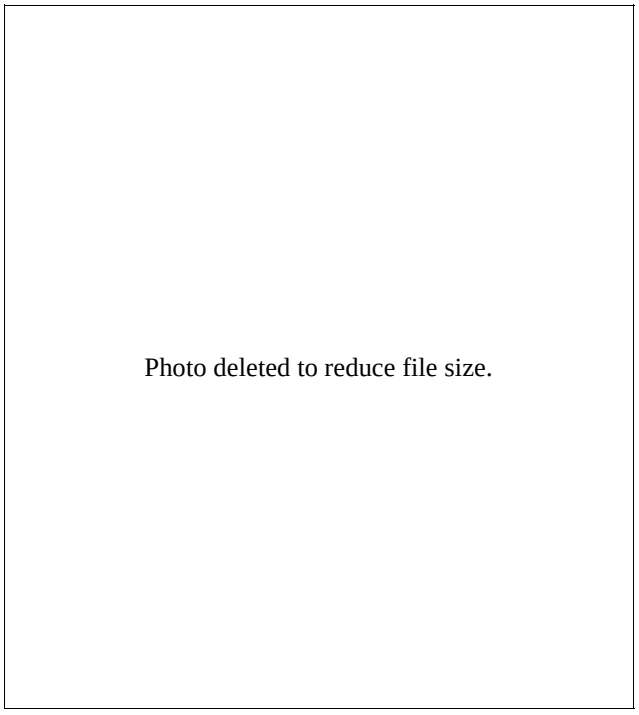

Figure 21. Deer and custom-slaughtered carcasses in a meat cooler.

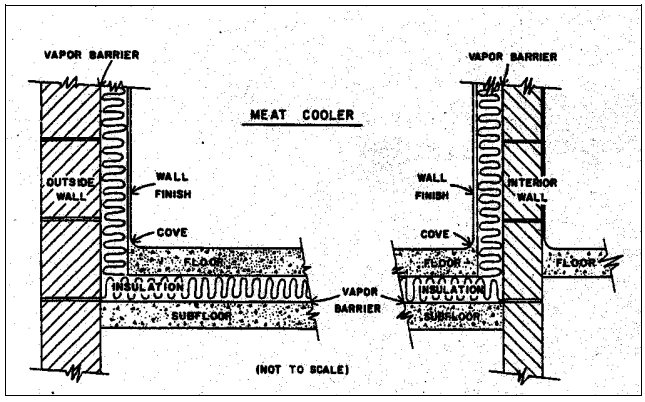

Figure 22. Suggested method for constructing refrigerated room walls and floor.

cooler and the condenser is installed at another location (fig. 23).

The interior finish should be smooth and easily cleanable; the materials described for the slaughter floors are suitable for coolers also.

Overhead storage rails should be so arranged and carcass coolers, particularly chill coolers, should provide enough space that carcass sides or quarters do not touch. Rails must be far enough apart for a rail of carcass items to be moved easily between two adjacent parallel rails of stored items. Adequate space between the top of the overhead rails and the ceiling improves air circulation throughout the cooler. In most small coolers, a vertical distance of about 2 feet is ample to accommodate rail hangers, hanger support beams, and air circulation. The number of carcasses placed in the cooler, species handled, average dressed weight, and typical carcass unit (side, quarter, or cut) influence the space requirements. Suggested space allocations for planning rail-equipped coolers are shown in table 2.

Carcass chill cooler

The type of refrigeration provided for chilling can have a direct effect on the condition and shrinkage rate of carcasses. Most authorities on refrigeration equipment recommend an optimum cooler temperature of about 32° to 34° F, relative humidity of 90 to 95 percent, room air temperature 10° F higher than the surface of the refrigeration coils, and a per-hour air circu-

Table 2. Space allocations for planning overhead rail layouts in carcass chill and hold coolers, by cooler, species, and carcass unit.

Cooler, species, and carcass unit	Carcass average dressed weight (pounds)	Vertical measurement, floor to rail top (feet)	Horizontal measurement		
			Wall to rail (feet)	Rail spacing (inches)	Trolley spacing (inches)
Chill coolers:					
Beef sides	150–349	[1]11	3	30	12
	350–599	[1]11	3	30	15
	600–900	[1]11	3	36	18
Beef quarters	150–349	[2]7.5	3	30	12
	350–599	[2]7.5	3	30	15
	600–900	[2]7.5	3	36	18
Hog sides, head on	All wts.	[3]10	3	30	8
Hog sides, headless	All wts.	[3]9	3	30	8
Hold or sales cooler:					
Beef sides	150–349	[1]11	3	27	10
	350–599	[1]11	3	30	12
	600–900	[1]11	3	33	14
Beef quarters	150–349	[2]7.5	3	27	10
	350–599	[2]7.5	3	30	12
	600–900	[2]7.5	3	33	14
Hog sides, head on	All wts.	[3]10	3	26	7
Hog sides, headless	All wts.	[3]9	3	26	7

[1] Based on 15-inch trolleys.
[2] Based on 15-inch trolleys for hindquarters.
[3] Based on 12-inch trolleys.
Sources: *2*, *8*, and *11*.

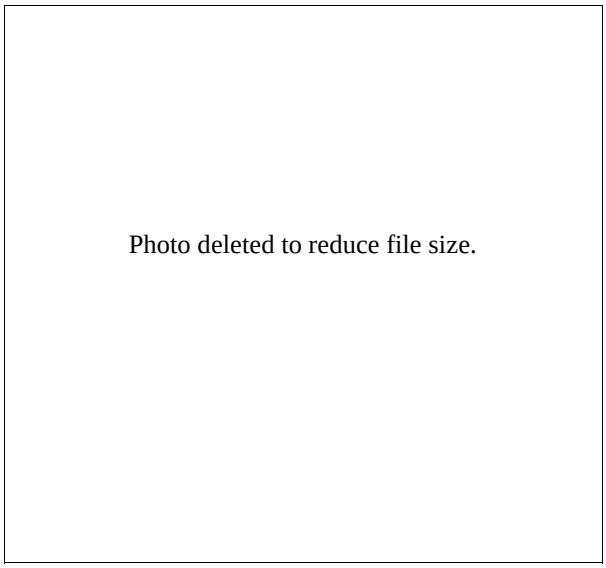

Figure 23. Remote refrigeration system.

lation rate about 60 to 100 times the room volume, to prevent formation of surface slime on carcasses and minimize shrinkage *(2, 3)*

The slaughter plant layout in figure 5 allows about 32 feet of overhead rail for chilling carcass sides. This will hold 16 beef carcasses at dressed weights up to 400 pounds, 12 beef carcasses at dressed weights up to 600 pounds, or 24 hog carcasses (table 2). A carcass-retaining cage is located in one corner; it can be folded against the walls when not in use.

Carcass hold cooler

The refrigeration equipment in most hold or sales coolers reduces the average internal temperature of chilled carcasses placed in them about 10° F to the optimum storage temperature, 33° to 35° F *(3)*. To avoid excessive shrinkage during storage, 6 to 12 air changes per hour are needed *(2)* **.** The relative humidity and difference between room-air and coil-surface temperatures recommended for this cooler are the same for the chill cooler (3).

The slaughter plant layout in figure 5 has a hold cooler with about 65 feet of overhead rail for storing carcass sides. About 32 beef carcasses weighing up to 600 pounds dressed or 55 hog carcasses or any combination of the two species can be held at one time (table 2). Along one wall, 10 feet is provided for shelving for small cuts and for holding returned products.

The nonslaughter plant layout in figure 6 allows about 77 feet of overhead storage rail in the hold cooler. About 19 quartered beef carcasses weighing up to 600 pounds dressed, 33 quartered pork carcasses, or any combination of the two species can be held at one time (table 2). Eleven feet of wall space is provided for shelf storage of small meat cuts and holding returned products.

Cure cooler

Cure coolers are used to hold products while they are in cure and to store cured and smoked products until they are sold. Cure work also can be performed in this cooler. Since most products are stored for only a short period, the recommended cooler conditions are as follows: temperature, between 38° to 40° F; relative humidity, about 80 percent; and an air circulation rate providing three to four changes per hour.

A typical cure cooler contains several cure vats or wheeled tub trucks, stationary or wheeled racks for hanging products, and shelves along wall to hold products until they are sold. It is difficult to relate floor space requirements to volume prepared, since many different procedures and types of equipment are used for curing and storage. However, cure vats that will hold about 500 pounds require about 14 square feet of floor space, and about 500 pounds of cured products can be hung on stationary or wheeled racks occupying about 12 square feet.

A combined cure cooler and cure workroom is provided in the slaughter and nonslaughter plant layouts, shown in figures 5 and 6, because of their relatively small volume. The room is equipped with a ham-pump table, cure storage tank and pump, lavatory, knife and small—saw sterilizer, and several large containers or trucks. The hams and bacon sides are cut and trimmed in the fabrication room. If all meats are placed in dry cure, they can be held on stainless steel shelves or movable racks along the walls, and the containers or trucks are not needed. Meats in dry cure lose moisture, and drain pans may be required between shelves.

Meat Freezer

Nearly all plants have a freezer for packaged meats. Some plants freeze the packaged meats in a separate quick freezer or a special compartment in the storage freezer and the next day

transfer them to storage in customer containers. Other plants freeze and store in the same freezer and do not rehandle packages until the customer takes them. The average time frozen meats are stored depends on the facilities available. Plants with freezers that will hold about a week's production require their customers to pick up orders soon after they are frozen; those with large freezers often provide lockers, baskets, or bulk storage for rent on monthly or yearly contracts.

To obtain maximum frozen-storage life and minimize shrinkakge, most refrigeration authorities recommend an optimum quick freezer temperature of —10° to —20° F, relative humidity of 85 to 90 percent, a temperature difference between room air and refrigerant coil surface of 10° to 15° F, and a circulation rate of at least one to two air changes per hour.

Storage freezers should hold a temperature of 0 F or below, a relative humidity and temperature difference the same as for the quick freezer, and an air circulation rate of two to three air changes per hour.

The best possible storage life of meat products is obtained by freezing them as fast as possible. Drip loss (moisture lost during freezing) in meats generally increases with slower freezing and in storage at temperatures above 0° F. Other factors that affect drip loss are duration of storage, amount of unfilled space in the package, quality of package moisture barriers, product surface area, and partial thawing and refreezing *(3).*

Freezer storage space requirements depend on the type or combination of types provided. In a number of the plants studied, the weight of packaged meats stored in lockers ranged from 25 to 35 pounds per cubic foot because packages were of odd sizes and shapes and could not be packed tightly. An average of 30 pounds of meat products per cubic foot is assumed for computing locker capacities. Since the average locker contains about 6 cubic feet of storage space, an allowance per locker of 180 pounds is reasonable. Most lockers are about 24 inches wide and 30 inches deep, and if they are stacked five high, 900 pounds can be stored in a 5-square-foot area. This is the equivalent of 180 pounds per square foot of floor space.

Storage racks for wire baskets are also used for customer orders. The racks are made of vertical metal posts with horizontal cleats to hold the baskets. Several basket sizes are used, the most popular one being about 17 inches wide by 28 inches long by 5 inches high and holding 45 pounds of product. If the racks are 8 feet high, 15 baskets or 675 pounds can be stored in an area about 18 inches wide and 29 inches deep (186 pounds per square foot).

Some plants have four or five tiers of metal or wooden shelving about *2* feet wide around the walls of the freezer for storing packaged products, with the top shelf about 5 feet above the floor. The storage capacity per square foot of floor space depends on the number of shelves and the average weight of product per square foot of shelf. About 100 pounds of product per square foot of floor space probably would be average for shelf storage.

Meat freezers need well-insulated walls, floor, and ceiling. On the warm side of the insulation, a good vapor barrier is necessary to prevent reduction of insulation efficiency owing to moisture buildup. The floor should be above ground or designed so as to prevent buckling caused by formation of ice under the floor. For good air circulation, space is needed between the stored product and ceiling, walls, and floor. Aisles at least 3 feet wide are recommended, and they should not be used for overflow storage.

The freezer in the slaughter plant layout in figure 5 is located in one corner of the building so that it can be enlarged without changing product flow in the plant and without any other remodeling within tile building. A ceiling height of at least 9 feet is suggested to insure adequate air circulation above the lockers and baskets. A separate quick freeze room or compartment is not shown, but could be accommodated by reducing the number of lockers and baskets in the room. The maximum capacity of the freezer is 51,525 pounds. Since customers are allowed to visit their lockers at most plants, a second door for this purpose opens into the office and sales area (inspection does not allow customers inside the fabrication room, *11).* To prevent pilferage from the basket storage, a partition with a locked gate or door should be placed between the locker and basket storage areas.

The nonslaughter plant freezer shown in figure 6 is also easy to expand. It has two doors, one leading to the salesroom and the other to the quick freeze room. The quick freeze room will hold 12 freezer carts loaded with 7 baskets each, for a total of 3,780 pounds. The holding freezer

has a capacity of 31,050 pounds when all lockers and baskets are full. If customers are allowed to visit their lockers, a partition with a locked gate or door should be placed between the locker area and basket area.

Fabrication Room

Primal cuts, quarters, sides, and whole carcasses are moved from the coolers to the fabrication room, where customer cuts are prepared (fig. 24). The customer cuts include bone-in and boneless steaks, chops, and roasts; bulk ground meats and patties; sliced bacon; fresh sausages; and tenderized cuts. After meat cuts are packaged, weighed, and labeled, they are placed in the freezer.

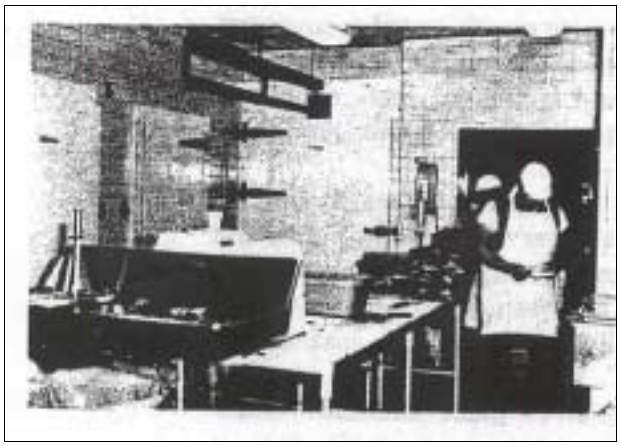

Figure 24. Fabrication room.

The room should be well insulated and refrigerated to control bacterial growth. Many authorities recommend a room temperature between 45° and 50° F, a relative humidity from 45 to 50 percent, a room air temperature about 20° F higher than the surface of the refrigeration coils, and an air circulation rate of about 6 to 10 changes per hour as optimum conditions for both product protection and worker comfort.

Fabrication room space requirements are determined by average daily volume handled, space needed for equipment and workers, aisles for moving and holding products, and an allowance for flexibility in product preparation. Average daily volume handled is the major factor that determines the number of workers in the room. Research results show that a worker can prepare or package from 600 to 1,200 pounds of carcass meats in an 8-hour day. Preparation includes selecting meat cuts in the cooler, transporting these cuts to the work area, and cutting customer meats. Grinding, weighing, wrapping, labeling, moving, and placing products in the freezer are jobs generally performed by workers who package meats.

Plants with lower daily output often have workers performing many peripheral duties such as obtaining packing supplies, serving customers, removing products from the freezer for customers, and plant cleaning.

Space requirements for equipment are based on the items required to produce the customer cuts and the daily volume prepared. If a plant prepares only bone-in and boneless meat cuts and bulk ground meat, the equipment needed is a fabrication table, bandsaw, meat grinder, slicer, scale, package table, sink, small-tool sterilizer, and lavatory. A worker should be provided with at least 4 feet of space along each fabrication table and 3 feet along each package table. For trimming smaller bone-in primal cuts and sawing steaks and chops efficiently, the band-saw should have at least a 1½-horsepower motor.

Meat grinders generally produce ground product at less than the manufacturer's rated capacity, since the worker hand-blends the meat before placing it in the grinder head and tries to minimize product heating by not overloading the grinder head. Some related research on grinding meats indicates that a worker can blend, coarse-grind, change plates, and fine-grind 200 pounds of meat trimmings in about 24 minutes with a 5-horsepower grinder and in about 22 minutes with a 7½-horsepower grinder *(5)*. The temperature of the meat, size of the trimmings, condition of the grinder knife and plate, and ability of the worker to keep the grinder heat adequately supplied with meat directly affect the rate of production with any size of meat grinder.

Aisles must be wide enough to permit the movement of products to and from the work stations and to provide ample space for temporary storage of meat carts, freezer baskets, and offal containers. Aisles should be wide enough at cooler, freezer, and other doorways to permit workers to remain at their work stations when the doors are opened behind them. When overhead rails for carcass transport are located in aisles, the aisles must be at least 5 feet wide *(11)*.

Many plant owners have found that lack of a few square feet of extra floor space has prevent-

ed them from hiring extra workers during peak volume periods, adding new equipment such as meat mixers and sausage stuffers for new products, or replacing tabletop equipment with larger floor units. Because this is a common occurrence, it is recommended that at least one extra workspace be provided over and above what is needed at the fabrication and package tables, and that about 6 square feet of floor-space be reserved for future addition of equipment.

The fabrication room of the slaughter plant shown in figure 5 is located in about the center of the building, convenient to all storage and work areas. In this room, the ceiling should be at least 10 feet high except in the area in front of the hold cooler; in an area about 6 feet wide and 12 feet long, it should be at least 12 feet high to permit the 11-foot-high cooler rail to extend into the room and to provide space for a quarter dropper. The quarter dropper lowers a hindquarter from an 11-foot-high rail to a 7½-foot-high rail.

If the plant volume increases, the fabrication room is large enough for equipment and workspace for four meatcutters, a bandsaw operator, a meat grinder and package worker, and four full-time package workers. With 10 full-time employees, about 4,500 pounds of product can be prepared and packaged daily, based on an average production of around 900 pounds per worker. This represents a 29-percent increase above the design volume of about 3,480 pounds per day. In calculating daily volume, the average dressed weight assumed for cattle carcasses is 400 pounds, and for hog carcasses, 180 pounds. The 1,500 pounds of pork placed in cure and smoked weekly is handled by other workers.

The nonslaughter plant fabrication room in figure 6 is located similarly to the one on the slaughter plant layout. Except for the addition of a patty machine, this layout has the same major equipment items as the slaughter plant.

Adequate workspace is provided for up to 10 part-time or full-time workers. To handle the assumed daily volume of about 2,720 pounds, the equivalent of six full-time employees is needed, based on the average daily production of 900 pounds per worker.

Cure Room

Plants that handle a significant number of hogs also may cure hams, bacon, specialty cuts, and sausages. Since the cure ingredients can adversely affect the quality of fresh meats, plants have a separate room for placing meats in cure. Here, the cure solution is prepared and pumped into hams and shoulders, and hams, shoulders, bacon, and specialty cuts are either rubbed with dry cure and place in vats or on shelves or are placed in vats filled with the cure solution.

It is recommended that the cure room be insulated, refrigerated to about 40° F, and built much like the fabrication room.

The space requirements can vary depending on the volume prepared and the amount of equipment needed. The room should be large enough for a cure-pump table, a supply of cure solution, a cartload of meat items to be placed in cure, one or more cure vats or tubs, lavatory, a small-tool sterilizer, workspace for one or more employees, and sufficient aisle space for moving products into and out of the room (fig. 25).

Stainless steel is recommended for most equipment, since it is very durable and does not corrode when exposed to cure ingredients. Some plastic equipment has been approved for curing work and, if handled properly, can last indefinitely.

Some plant operators place the cure workroom in cure cooler since cure work often is done only part time. This scheme reduces the number of rooms, the floor space requirements, and total product handling. The temperature of the combined cure workroom and cooler should he the same as for the cure cooler.

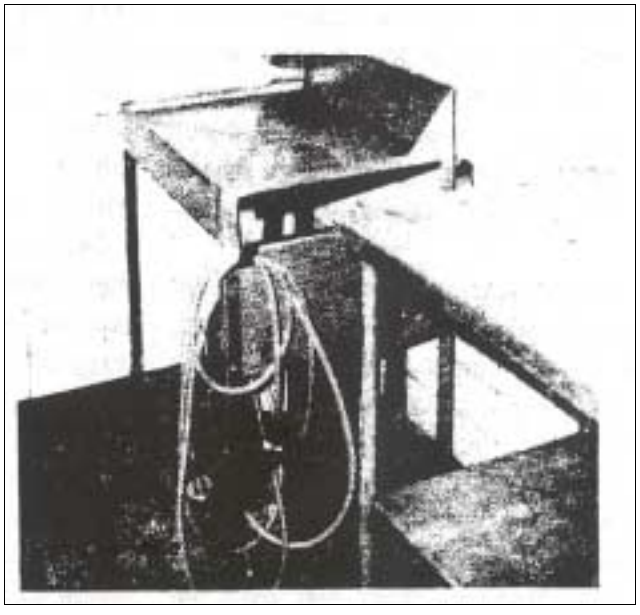

Figure 25. Cure-pump table.

Smoke Room

Plants that cure meats generally have a separate room for one or more smokehouses. This room can also be used for rendering lard, cooking chili, and the like.

Smoke rooms are not refrigerated. Smokehouses must be vented to the outside and if other cooking equipment, such as a chili kettle, is used, it should have a hood and also be vented to the outside *(11)*. An exhaust fan is recommended to remove excess heat and smoke from the room. The type of construction and materials used are the same as for the slaughter floor.

The floor space required in addition to that needed for the smokehouses and cooking equipment is limited. Enough clearance to open the smokehouse doors, space around the equipment to service and clean it, floor space along a wall to wash products removed from the smokehouses, and aisles to transport products are all that is required.

Four types of smokehouse equipment are used in these plants: (1) cages suspended from an overhead rail, (2) four-wheel trucks, (3) individually placed sticks, and (4) ceiling hooks for hanging products. Capacity of smokehouses for cages on overhead rails or for four-wheel trucks is typically from one to six loaded units. An average load for a cage or truck is 400 to 500 pounds. For sticks, the capacity depends on the type of smokehouse and dimensions of the smoke area. One popular cabinet-type smokehouse, with burners in the bottom, will hold about 300 pounds on sticks. A similar larger unit holds up to 450 pounds (fig. 26). Smokehouses with ceiling hooks usually are designed and built by the plant operator and their capacity depends on the size of the smoke area and how the products are spaced.

A smokehouse with a capacity between 400 and 500 pounds is recommended for the plant layouts in figures 5 and 6. The smoke room for these plants should also be equipped with hot-and cold-water hose connections and an exhaust fan.

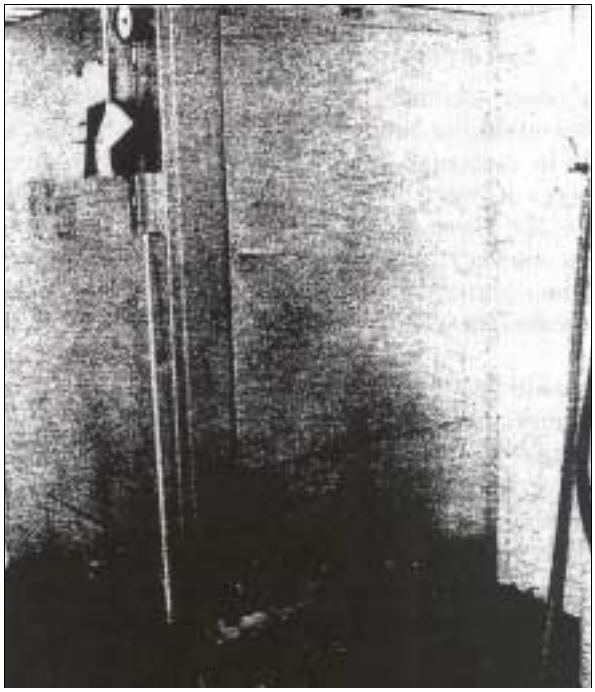

Figure 26. A smokehouse that holds about 450 pounds. This smokehouse is an exempt plant. In an inspected plant, at least a 12-inch clearance is required between the smokehouse and the building walls and floor except when the smokehouse is sealed to walls and floor.

Dry Storage Room

Packaging supplies, spare parts, extra equipment, and related items are stored in this room. Many plants have less than 100 square feet of floor space available for dry storage—often not enough to maintain an adequate inventory— and have had to build or rent additional storage space.

Dry storage rooms need to be well built to protect the contents from dampness and airborne dirt, to prevent the entrance of insects and rodents, and to facilitate good housekeeping. Concrete floors and concrete block or rust-resistant metal walls are typical materials used for these rooms. While metal storage racks, shelves, and pallets are preferred, wood can be used if it is kept in good repair and is easily cleanable. To allow for floor cleaning under stored items, all storage racks should be raised at least 12 inches above the floor *(11)*.

The dry storage rooms shown in the plant layouts are located conveniently to the receiving area and the fabrication room, where most of the supplies are used. The water heater is located in one corner of the room in the non-

slaughter plant layout, close to the areas where most of the hot water is used.

Spice Room

Plants that make sausages, cured meats, or meat products containing binders or extenders need an ingredient storage area. If only pre-weighed packages of ingredients are used, shelf space set aside for these packages in the dry storage room is adequate. A separate spice room is suggested when ingredients are purchased in bulk and are measured, weighed, or mixed prior to use.

The room should be well constructed to keel out dampness, dirt, and insects, and be easy to clean. Ingredients must be stored at least 12 inches above the floor on either metal racks, shelves, or pallets, or on wooden ones if they are kept in good repair and are easily cleanable *(11).*

In addition to storage space, the room needs a table, scales, and measuring and mixing equipment.

The spice room location in the slaughter plant layout is not as convenient to the cure work area as the one shown for the nonslaughter plant. This relatively distant location is acceptable, however, since the cure worker should be able to obtain all the ingredients needed for a day's operation in one trip.

Offal Room

An offal room in a small meat plant is used to store inedible byproducts temporarily. In slaughter plants, viscera, feet, condemned parts, bones, excess fat, and other items not for human consumption are stored in this room. If hides are sold green or if blood is caught during bleeding, these containers may also be stored in the offal room. Plants that do no slaughter need an offal room for containers of bones, fat, and inedible trimmings. In some instances (because of small volume or reliable, frequent pickup) meat inspection may not require an offal room *(10).*

If offal is not picked up daily, the room should be artificially cooled to about 40° F.

In low-volume plants, the offal room is used almost entirely for the storage of inedible byproduct containers. Larger plants that slaughter more than one head at a time may have a paunch worktable and paunch truck wash and sterilize area in the offal room in addition to tile containers. The smallest practical paunch worktable is about 4 by 9 feet. A paunch truck wash and sterilize area requires a space about 7 by 8 feet *(11).*

The amount of floor space needed to store byproduct containers can be determined roughly if the approximate amounts of byproducts to be

Table 3. Average number of animals handled for each 55-gallon barrel for selected work areas, livestock species, and types of byproduct placed in barrel.

Source of byproducts	Av. dressed carcass weight (pounds)	No. animals per barrel[1]
Slaughter floor:		
Cattle:		
Head, feet, viscera	350–450	4–5
Stomach contents	350–450	2–4
Blood	350–450	10–12
Hide	350–450	6–8
Hogs (skinned):		
Head, feet, skin, viscera	150–200	8–12
Stomach contents	150–200	6–8
Blood	150–200	42–48
Hogs (dehaired):		
Viscera	150–200	10–20
Stomach contents	150–200	6–8
Blood	150–200	42–48
Fabrication room:		
Cattle: Fat, bones, trim	350–450	2
Hogs: Fat, bones, trim	150–200	5

[1] Barrels used for the stomach contents and blood are considered full in most plants when within 2/3 to 3/4 capacity.

stored and the sizes of containers to be used are known. Some rule-of-thumb requirements for 55-gallon barrels by livestock species, dressed weight, and type of byproducts are shown in table 3. While a 55-gallon barrel occupies about 3 square feet of foorspace, about 4 square feet should be allowed per barrel to permit easy movement into and out of storage.

About one-third of the foorspace shown in the slaughter plant offal room is needed to hold the offal barrels for a typical day's operation. The remaining space is for an aisle, a small paunch worktable, and extra barrel storage. The offal room in the non-slaughter plant layout holds about ten 55—gallon barrels, with room left for a narrow aisle.

Hide Room

Many livestock slaughter plants have a room for curing cattle hides. The hides are put into the curing area as they are removed or at the end of the day's slaughter. Ideally, the hides are trimmed and cleaned, and then spread out hair side down in a curbed area, covered with coarse salt, at the rate of about a pound of salt to each pound of hide, and cured for about 30 days before they are sold. The temperature of the hide room should be about 50° to 55° F, with a relative humidity of 85 to 95 percent to get the best cure (1) . Some slaughterers sell hides "green." Green hides are placed in containers in the offal room, and a buyer picks them up several times a week.

The hide-curing area can be located adjacent to the slaughter floor, in the basement, or in a separate building (figs. 27 and 28). There are advantages and disadvantages to each location. A hide room near the slaughter floor is most convenient for disposing of the hides, but is usually, the most costly because of the type of construction required by meat inspection. Another disadvantage is that in hot weather a disagreeable odor from the hide room may penetrate the entire plant. A basement room is naturally cool, and hides can he dropped through a vented chute from the skinning area to the hide room, but a basement hide room can be expensive because of the extra excavation and building foundation required, unless the plant is located on a hillside. A separate hide house can be built of relatively inexpensive materials in almost any configuration. The major disadvantages of a separate hide house is distance from the slaughter floor, which makes for discomfort for workers transporting hides in inclement weather.

A suggested design for a separate hide house is shown in figure 29. The drawing shows the pit below ground level; however, it could be located at or above ground level if necessary. Hides located below ground level should be cooler in summer. To prevent saltwater from leaking into the surrounding soil the pit floor and walls should be waterproofed. When the pit is emptied of hides, the standpipe can be removed and the walls and floor cleaned before a new hide cure cycle is started. The 2-foot-high standpipe allows brine to accumulate around the hides in cure. The ventilators at each end

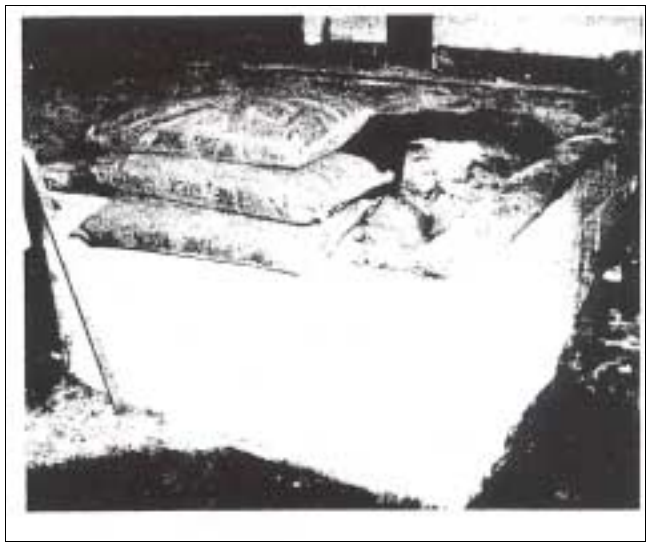

Figure 27. Hide-curing area adjacent to slaughter floor.

Figure 28. Hide-curing area in a separate building.

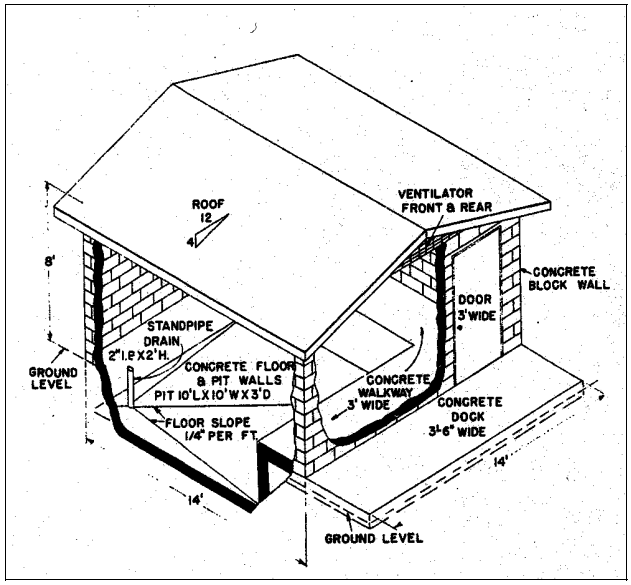

Figure 29. Perspective drawing of a suggested hide house with a capacity of 300 hides.

of the roof allows air to circulate through the building. Since salt is very corrosive, either wood or rust-resistant ventilators are recommended. The walkway, on two sides of the pit, is for temporary storage of hides and salt storage. The hide house door can be of treated wood or noncorrosive metal. A galvanized-metal or aluminum roof is suggested.

The pit size shown will handle hides from average-size cattle and provide space for a narrow walkway on two sides. Based on a storage factor of about 1 cubic foot per hide, it should hold around 300 hides.

A separate hide house similar to the one shown in figure 29 is suggested for the slaughter plant in figure 5. This plant will produce about 120 hides in a 30-day cure cycle; a hide pit depth of between 1 1/2 and 2 feet will handle that volume and allow for a modest increase as well.

Product Shipping and Receiving

A dock for shipping customer orders and one or more receiving docks are needed at most plants. If carcass meats are purchased, the shipping dock also can be used for receiving meats. A dock not in use for loading or unloading meats can be used for receiving dry storage supplies, plant equipment, and similar items.

A dock can extend out from the building or be located inside the building near a doorway in the outside wall. For small plants, the outside dock is recommended for shipping and receiving carcasses because it is usually less expensive than interior space, and the plant door can be kept closed except when products are passing through. The outside dock floor should be concrete, sloped down toward the outer edge at about one-eighth inch per foot. A dock height of about 24 inches should be adequate for serving small trucks and automobiles, and from 42 to 48 inches, for refrigerated trucks. To protect meat products from inclement weather, a roof is required over an outside dock *(11).* If the dock roof extends beyond the edge of the dock floor, the lowest part of the roof should be at least 12 feet above the driveway to clear refrigerated bodies on small trucks, or 14 feet to clear trailer trucks.

A covered dock is shown in both the slaughter plant layout (for loading meats into customer trucks and receiving supplies) and in the non-slaughter plant layout (for receiving carcass quarters and wholesale cuts). Both docks have an overhead rail for moving meat cuts hung on trolleys. Both layouts have a corridor that connects the dock to the plant storage and work areas. A track scale is located in the corridor for weighing meats hung on trolleys. To help keep insects out of the plant, a fly-chaser fan, air door, or other device should be installed over the doorway *(11).*

Inspection Office

A meat inspection office may or may not be required at a small meat-processing plant. The area meat inspection official can determine if an office is needed when the operator visits the area office to discuss plant location, building plans, type of business, and volume to be handled. If an office is not required, the inspector must be provided with a place to store supplies and clothing and desk space to prepare reports
(10).

A meat inspection office is shown on both plant layouts in figures 5 and 6, since plants handling these volumes probably would have a full-time inspector. The inspection office for the nonslaughter plant is not provided with a shower bath since it is not required *(11).*

Employee Welfare Facilities

Employee welfare facilities include dressing rooms, toilets, shower baths, and lunchrooms.

When both sexes are employed, separate dressing rooms and toilets are required. If suitable restaurants are not available nearby, a plant may be required to provide a lunchroom (11).

The slaughter plant layout includes a dressing room and toilet room for the female employees and a dressing room and a combined toilet and shower bath room for the male employees. In the nonslaughter plant layout, dressing rooms and toilets are provided for both sexes. Employee lunchrooms are not provided since it is assumed that acceptable eating facilities are located nearby.

Plant Offices

The amount of office space to include should be decided on at the same time the operator develops plans for the remainder of the plant. Offices in the plants studied ranged from a desk in one corner of a combination salesroom and business office to several rooms for the bookkeeper, plant operator, and customer sales. In most cases, operators who did not have private offices expressed a desire to include one when planning a new plant.

There are no guidelines available for determining office size based on volume or type of business; therefore, only recommendations based on observations are made in this report. Office space at a business with few visitors should contain at least 100 square feet since a desk, two chairs, and two file cabinets will consume about one-third of the total space. If meat display cases for customer sales are to be provided, then the space allocation should be 200 square feet or more.

The plant office and sales area are combined in the slaughter plant layout; however, a private office of about 8 feet square is provided for the manager. The nonslaughter plant layout has an office area and a salesroom. The office area also has a private office for the manager and a toilet for the office employees.

Plant Utilities

At 13 plants in Texas and Oklahoma, the livestock volume and utility requirements were obtained for 1 month's operation (table 4). The total utility costs shown in the table were computed from averaged rates for October 1974 and do not reflect the actual bills paid by these plants. A relationship was not established between the number of livestock handled and utility consumption, because too many variables were present. A person planning to construct a new plant should be able to use the average data in the table to roughly establish what his utility requirements and costs will be based on the anticipated volume to be handled.

An adequate electrical supply, an ample water source, and a good sewer system are necessary in order to operate a modern meat plant. When competitively priced, natural or liquefied petroleum gas usually supplies a portion of the energy requirements at these plants.

Three-phase 220- or 440-volt electrical service is needed to operate the electric motors for refrigeration, hoists, dehairers, meat grinders, meat saws, and other large equipment items. The lights and small equipment generally operate with a single-phase 110-volt service. Since many work areas have damp or wet floors and

Table 4. Livestock volume, utility consumption range, and utility cost for 1 month for 13 plants in Texas and Oklahoma.

TABLE 4.—*Livestock volume, utility consumption range, and utility costs for 1 month for 13 plants in Texas and Oklahoma*[1]

Utility range	Livestock volume	Utility consumption			Total utility costs[2]
		Electricity (kilowatts)	Water (gallons)	Gas (Cubic feet)	
Lowest[3]	115	5,776	6,610	7,500	$231.02
Highest[4]	530	28,320	193,600	173,000	911.92
Average	199	20,061	51,109	32,620	564.75

[1] Plants handled from 72 to 530 head of livestock during the month when utility data were obtained.

[2] The total utility costs were computed from averaged rates for October 1974, and they include cost adjustments for fuels for generating electricity, purchasing natural gas, and sewer charges.

[3] Nonslaughter plant.

[4] Livestock slaughter plant that also prepared and smoked poultry products.

require that water be used around electrical equipment, all electrical outlets should be waterproof and the outlets and equipment adequately grounded to prevent shorts or shocks to workers. In the fabrication room it is recommended that electrical outlets for equipment plug-ins be suspended from the ceiling and wall outlets eliminated. Ceiling-suspended outlets eliminate cords on the floor and possible wall plug shorts during cleaning.

It is suggested that whenever practicable fluorescent lamps be used for interior lights. Fluorescent lamps provide from 3 to 4 times more light per watt than incandescent lamps, produce less heat, and have a bulb life 7 to 10 times longer (6).

Water supply and pressure should be adequate to meet the peak demand, which normally occurs during plant cleanup at the end of a day's operation. The recommended pipe size for hose connections is 3/4-inch-inside diameter, and for lavatories, sinks, toilets, and shower baths, ½-inch-inside diameter. The plant service line and branches should be large enough to prevent a noticeable drop in pressure and reduction in flow rate when more than one outlet is in use. Water flow through the hoses was measured in four plants. The highest rate, about 8 gallons a minute, was through a 5/8-inch-inside-diameter hose, 25 feet long, used without a nozzle to clean the slaughter floor. A $^{5}/_{8}$-inch-inside-diameter hose, 27 feet long, which was used without a nozzle to clean livestock pens, had the lowest rate of about 2 1/2 gallons a minute. At all four plants, whenever a second hose or outlet was turned on, the pressure and flow rate of the first hose dropped off significantly, hut was not measured when two or more hoses or outlets were in use.

A plant that slaughters should have a heater capable of supplying 180° F water, and a nonslaughter plant should have a heater supplying 140° F water (10). The 180° F water should be available at hose outlets for cleaning, slaughtering, inedible offal, and similar areas and for sterilizing equipment such as viscera inspection trucks (11). Water at 180° can cause burns; therefore, all other hot-water outlets in the plant should be supplied with 140° water. A slaughter plant can have a 180° water heater and a 140° water heater or one 180° water heater with a tempering valve that automatically mixes cold water with the supply to general-purpose outlets.

Commercial quick-recovery water heaters are recommended to provide the extra heating capacity needed during peak demand. A hot-water storage-tank capacity of at least 100 gallons for slaughter plants and 85 gallons for non-slaughter plants is suggested for even the smallest volume plants. These capacities are suggested because only about 70 percent of the storage capacity at the thermostat setting can be used during a peak demand period before the incoming cooler water significantly lowers the temperature of the remaining 30 percent (3).

In some areas, the water is hard because of high mineral content. Hard water heated above about 140° F can deposit the minerals on the interior surface of the hot-water storage tank and piping. These deposits will continue to build up, and in a relatively short period the water heater efficiency and flow of water through the pipes are reduced. A commercial water softener connected to the cold-water supply to the heater can be used to neutralize the minerals in the water supply.

The sewer system must be acceptable to local or State health authorities before inspection can be inaugurated at a plant (11). If a municipal sewer system is not available, a slaughter plant may use a septic tank with a drainage field or a lagoon system. A nonslaughter plant probably can use the cheaper septic tank and drainage field system, but very little is available on lagoon design for small meat plants. To aid in planning a lagoon system, the following guidelines are presented. A lagoon system for the larger volume meat processors should have an anaerobic, a transition, and an aerobic pond (fig. 30). The wall slope shown is recommended to reduce wall erosion, and the dike height and width, to minimize the need to obtain a significant amount of soil during construction.[4] If lagoons are located in porous soils, a bottom and wall liner of nonporous material may be needed to protect ground water from possible pollution. Gases are produced by lagoons, and high sulfate concentration in the raw water supply can

[4]Witherow, .J. L. Preliminary design of cooperative development and demonstration project on waste treatment systems suitable for small meat packing plants. U.S. Department of the Interior, Washington, D.C. 14 pp. 1970. (Internal report.)

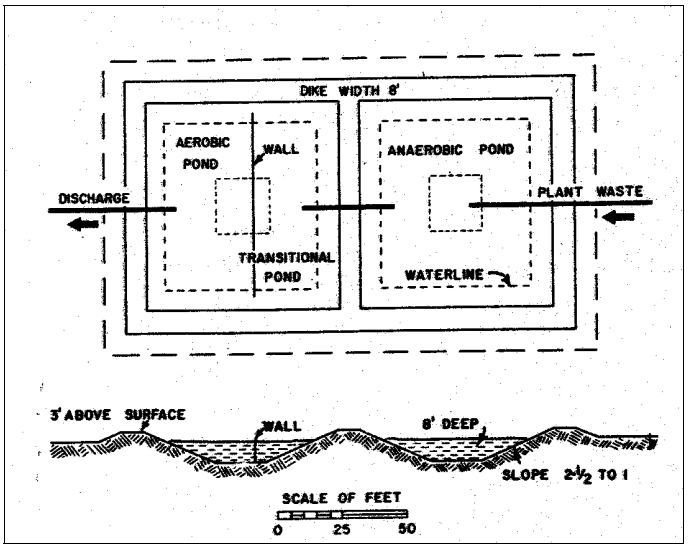

Figure 30. Layout of a lagoon system.

produce an unpleasant hydrogen sulfide odor in the area. In general, if the sulfate content of the water is less than 100 parts per million, the odor is insignificant, but if it is 200 parts per million or more there can be an odor problem. If possible, lagoons should be located at least a half mile from any dwelling or other place of business.

The criteria used in designing several successful lagoon systems were to provide at least 1 acre-foot (43,560 cubic feet) of storage in the anaerobic lagoon for each 500 hog units, 180 to 240 pounds live weight, slaughtered each week and at least 1 acre-foot in the transitional and aerobic lagoons for each 670 hog units slaughtered each week. The latter volume should be divided about one-third to the transitional lagoon and two-thirds to the aerobic lagoon. For cattle slaughter, a live animal weighing less than 600 pounds is considered equivalent to 1 hog unit; between 600 and 900 pounds, 3 hog units; and over 900 pounds, 5 hog units (7).

A lagoon system constructed according to figure 30 requires at least one-half acre of land. Some local health officials allow both employee and plant wastes to be handled by the lagoon, while others require separate systems for human and plant wastes. Local and State officials should be consulted for guidance in planning the sewerage system for a plant.

Construction Costs

The construction cost for new slaughter or nonslaughter plants is estimated at $22 per square foot in rural areas and from $30 to $35 per square foot in metropolitan areas. The cost estimates include building construction and installation of refrigeration equipment, electrical wiring, plumbing, heating, doors, and overhead rails. The cost for new equipment in the plant can be estimated by multiplying plant square footage by $5. These estimates are based on actual costs for several new plants constructed in 1974 in the Southwest.

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